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Article

Feasibility Analysis of Establishing Multilateral Nuclear Approaches (MNAs) in the Asian Region and the Middle East

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Abstract: To establish frameworks for multilateral nuclear approaches (MNAs), we identified challenges and their possible solutions through case studies proposing to establish three different MNAs, comprising existing states in the Asian region and the Middle East, in accordance with twelve features deemed necessary for establishing MNAs. In all case studies, political instability of MNA member states and the region, as well as political conflicts between MNA member states and other states were seen as challenges hindering the establishment of MNAs. There are no simple measures to overcome such challenges, but additional case-by-case measures, including the direct involvement of international organizations, supplier states and nuclear weapon states, in MNAs, as well as the application of regional safeguards and regional systems of accounting for and control of nuclear material (RSAC) within MNAs, may contribute toward mitigating the political challenges.

Keywords: multilateral nuclear approaches; MNA; nuclear non-proliferation; Asia; Middle East

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1. Introduction

Multilateral nuclear approaches (MNAs) represent "a concept of international and/or multilateral control of nuclear material and/or nuclear fuel cycle facilities. It is a strategy for contributing to and

promoting the sustainability of peaceful use of nuclear energy while enhancing nuclear non-proliferation, by ensuring nuclear fuel cycle services, and risk control and reducing risk regarding nuclear safety" [1]. Furthermore, MNAs are a "confidence-and-security building measure" that "would seek to introduce transparency and thereby predictability in relations between States by clarifying national intentions, reducing uncertainties about national activities, and/or constraining national opportunities for surprise" [2].

Pursuant to these premises, since 2012, we have published three papers on MNAs. The first paper [1] identified twelve features necessary to establish MNAs and their preconditions. The second [3] and third [4] papers proposed, as measures to ensure a stable and smooth supply of nuclear fuel and nuclear fuel cycle services among MNA member states, ways to harmonize between MNAs and nuclear cooperation agreements (NCAs) along with nuclear third-party liability (TPL) systems within MNAs. If the number of states desiring to form MNAs jointly satisfy the twelve stipulated MNA features and their preconditions, it should be theoretically possible to establish an MNA.

In this paper, we conduct three case studies to analyze the feasibility of establishing MNAs. The case studies examine countries in Asia and the Middle East with regard to the twelve MNA features and their preconditions. In addition, any particular challenges related to establishing MNAs together with their possible solutions are identified.

None of the prior studies on MNAs have included case studies in accordance with MNA features and their preconditions; therefore, this paper should provide valuable suggestions for establishing MNAs in the future.

2. Twelve Necessary Features of MNAs and Their Preconditions

Box 1 briefly summarizes the twelve MNA features and their preconditions, including proposals, as identified in our previous papers, although some MNA features are renamed. The order of features and their preconditions is slightly modified from the preceding papers.

Box 1. The twelve MNA features and their preconditions.

(A) Nuclear non-proliferation

One purpose of establishing MNAs is to ensure nuclear non-proliferation; therefore, in principle, MNAs need to maintain strong nuclear non-proliferation characteristics, although MNA member states' rights to use nuclear energy for peaceful purposes must be respected in accordance with Article 4 of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Moreover, this strong characteristic is required for the granting of advanced consent by nuclear supplier states (NSSs) for recipient states' (RSs') engagement in sensitive enrichment and reprocessing (ENR) activities when utilizing nuclear material originating from NSSs and supplied under NCAs between NSSs and RSs (see Feature (D), "Nuclear cooperation agreements," below in Box 1).

Box 1. *Cont.*

In this regard, Paragraph 6(a) of the Nuclear Suppliers Group Guidelines (NSG Guidelines) [5] prescribes criteria according to which NSSs can authorize transfers of their ENR facilities, equipment and technology (ENR-related items) to RSs. In other words, this paragraph can be interpreted as stating that if RSs satisfy such criteria, they are recognized as having strong nuclear non-proliferation characteristics for the transfer of ENR-related items. Similarly, MNA member states must comply with the following treaties and conventions to maintain their MNA's nuclear non-proliferation characteristics for ENR transfers and thereafter engage in ENR activities:

- Nuclear Non-Proliferation
  - ✓ Treaty on the Non-Proliferation of Nuclear Weapons (NPT)
- International Atomic Energy Agency (IAEA) Safeguards
  - ✓ IAEA comprehensive safeguards (INFCIRC/153(Corr.)), if MNA member states are non-nuclear weapon states (NNWSs)
  - ✓ Additional Protocol (AP, INFCIRC/540(Corr.)) or equivalent safeguards, which has already been implemented by the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials ABACC (Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials)
- Nuclear Security
  - ✓ Convention on the Physical Protection of Nuclear Material (CPPNM, INFCIRC/274/Rev.1) and its amendment (Amendment to the CPPNM, not in force)
  - ✓ International Convention for the Suppression of Acts of Nuclear Terrorism (Nuclear Terrorism Convention)
  - ✓ Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5)
- Export Control
  - ✓ NSG Guidelines
  - ✓ UN Security Council Resolution 1540

In addition, to enhance the transparency of MNA's nuclear activities, as well as to promote confidence and security building among MNA member states, MNAs need to establish regional safeguards, regional systems of accounting for and control of nuclear material (RSAC) and common NSGs. The first two systems have already been implemented by the European Atomic Energy Community (EURATOM) and ABACC.

(B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services)

From a nuclear non-proliferation perspective, MNA needs to ensure the following supplies:

- ✓ Nuclear fuel (low-enriched uranium)
- ✓ ENR services
- ✓ If possible, spent fuel storage and/or spent fuel take-back (fuel leasing)

Box 1. *Cont.*

(C) Nuclear Safety

MNA member states must comply with the following international nuclear safety norms to maintain MNA's strong nuclear safety characteristics:

- ✓ Convention on Nuclear Safety (INFCIRC/449)
- ✓ Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546)
- ✓ Convention on Early Notification of a Nuclear Accident (INFCIRC/335)
- ✓ Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336)
- ✓ IAEA Safety Standards

In addition, MNA member states need to establish common nuclear safety standards and conduct nuclear safety peer reviews among MNA member states to maintain nuclear safety of MNA facilities.

(D) Nuclear cooperation agreements (NCAs)

To ensure the stable and smooth supply of nuclear material and nuclear fuel cycle services among MNA member states, as well as between MNA member states and non-MNA NSSs, the MNA as a whole (not as individual member states) must conclude NCAs with non-MNA NSSs and must grant the necessary advance consent for the MNA's ENR activities when utilizing non-MNA NSSs-origin nuclear material, as already takes place within EURATOM. To make such an arrangement possible, each MNA member state must have strong nuclear non-proliferation characteristics through the adoption of the measures described in Feature (A), "Nuclear non-proliferation," above.

(E) Nuclear third-party liability (TPL)

To ensure equal and non-discriminatory compensation for transboundary damage caused by nuclear accidents within MNA facilities, principally, all MNA member states with nuclear power (and those with plans to have it in the future) need to join the same international nuclear TPL convention. In addition, in certain situations and by agreement among all MNA member states, responsibilities of an installation state can be shared indirectly among all MNA member states through the following internal arrangements within the MNA, although a host state of an MNA facility in principle takes all responsibility as an installation state, in accordance with the international nuclear TPL convention to which the host state belongs, as well as the host state's domestic laws on nuclear TPL:

- ✓ Reimbursements paid to a host state based on pre-agreed shares and/or
- ✓ Making deposits on these reimbursements in the event of an incident.

Such an arrangement is based on mutual cooperation and sharing of responsibilities for nuclear safety among MNA member states. Furthermore, to avoid nuclear accidents, MNA member states need to maintain strong nuclear safety characteristics by following the international nuclear safety norms identified in Feature (C), "Nuclear safety," above.

Box 1. *Cont.*

(F) Siting: choice of host state (for MNA facilities)

An expert group's report on MNA in 2005 (the Pellaud Report) [6] offers three options regarding host states of MNA facilities: (1) "extra-territorial" status, (2) ENR technology holder states and (3) non-ENR technology holder states. Considering that MNAs are expected to be commercially feasible and the fact that existing MNAs, such as URENCO, have not been accorded "extra-territorial" status within their host states, there is no need to define this status unless an international organization, such as the IAEA itself, is actively involved in the MNA's decision making, management and operation, as well as in ensuring proper safeguards. If MNA facilities are ENR facilities, host states of such facilities are to be ENR technology holders, from the viewpoints of ensuring nuclear non-proliferation and protecting technology holders' intellectual property.

In addition, in general, host states of MNA facilities are required:

- To be members of the appropriate international treaties and conventions and to follow standards and guidelines on:
  - ✓ Nuclear non-proliferation (safeguards, nuclear security, physical protection of nuclear materials and facilities and export control), as mentioned above under Feature (A).
  - ✓ Nuclear safety, emergency preparedness and nuclear TPL, as mentioned above under Features (C) and (E).
- To be politically, socially and economically stable and to maintain good relations with neighboring states and the international community, as is discussed below under Features (J), (K) and (L), and not to have any territorial disputes with any states, including conflicts over natural resources.
- To ensure safe and secure routes for the transportation of nuclear material, including good access to international and domestic ports for the transportation of nuclear materials.
- To have necessary and sufficient knowledge, expertise and experience to host and operate MNA facilities, including the handling, storage and transportation of nuclear materials.

(G) Multilateral involvement and (H) Access to technology

As for Feature (G), "Multilateral involvement," according to the Pellaud Report, MNA member states' involvements vary and include the following roles:

(a) Supply-only arrangement,
(b) Sharing ownership of facility,
(c) Participating in the management of the facility,
(d) Participating in the operation of the facility and
(e) Joint research and development, design and construction of facilities.

Similarly, with regard to feature (H), "Access to technology," levels of access may include the following:

(f) None,
(g) Operational know-how,
(h) Maintenance know-how and
(i) Full access.

Box 1. *Cont.*

If MNA facilities are ENR facilities, non-ENR technology holders' involvements in MNAs and access to technologies need to be limited to Items (d) and (h) above, from the viewpoints of ensuring nuclear non-proliferation and protecting technology holders' intellectual property. In addition, the transfer of ENR facilities and technologies to non-suppliers or non-nuclear weapon states would be subject to the NSG Guidelines.

(I) Economics

In general, MNA facilities need to be commercially feasible and have economic advantage when compared with nation-based facilities, although the economics of MNA facilities are affected by various factors. In addition, a past study has clarified that an MNA reprocessing facility offers economic advantage over a nation-based facility, even if transportation costs are included; however, the MNA facility loses its economic advantage when the unit cost of land transportation is very high. [7]

(J) Transportation

Transportation routes between MNA member states, as well as between MNA member states and non-MNA NSSs must be carefully selected with consideration of Features (K), "Geopolitics," and (L), "Political acceptance," due to the necessity of obtaining authorization from relevant authorities in stopover states for transit and/or landing. To obtain such authorizations, MNAs need to be well accepted by the international community, including neighboring states and their local governments. In this respect, if states in the whole region share common regulations on nuclear energy, including nuclear security, nuclear safety, emergency preparedness and nuclear TPL, smooth and timely transportation can be expected.

In general, MNA member states need to comply with the international regulations on transportation by sea, air, rail, road, inland water and other means, along with the conventions mentioned in Features (A), "Nuclear non-proliferation," and (C), "Nuclear safety," above.

(K) Geopolitics

Political instability of a state or a region related to its geographical location severely affects a state's or region's ability to host MNA facilities. Unless it is able to alleviate such political instability, such a state or region cannot host an MNA facility. In other words, this feature requires political stability in a host state and/or its surrounding region.

(L) Political acceptance

MNAs need to be well accepted by the international community, including international organizations and non-MNA NSSs, to ensure the supply of nuclear material and fuel cycle services and to obtain the necessary permissions for the transportation of nuclear materials. In addition, past efforts in establishing MNAs indicate that the back-end of the fuel cycle in particular needs to be well accepted politically and by the general public. This goal can be advanced by enhancing the transparency of MNA facilities through information sharing and disclosure.

3. Case Studies

In this section, three case studies that envision the establishment of MNAs comprising existing states in the Asian region and the Middle East are conducted. In accordance with the twelve MNA features and their preconditions, the feasibility of establishing such MNAs is analyzed, challenges for establishment of these MNAs are identified and possible solutions to overcome these challenges are proposed. In each case, it is assumed that the prospective MNA member states have a desire to establish MNA-ENR facilities.

3.1. Case Study 1

Case Study 1 assumes that nuclear operators in Japan and the Republic of Korea (ROK) jointly form a Japan-ROK MNA and construct new ENR facilities in either Japan or the ROK and/or transfer existing Japanese enrichment and/or reprocessing facilities currently under construction to MNA facilities. In the case of a reprocessing facility in the ROK, it is assumed that pyroprocessing will be utilized in the future, although pyroprocessing technology is currently in the experimental stage in the ROK.

The two states have the following similarities and differences in their nuclear activities:

- Nuclear energy utilization and relations with the U.S.: Both Japan and the ROK are advanced nuclear energy states. However, due to their lack of natural resources, both states have been provided with nuclear supplies from the U.S. under NCAs with the U.S. to initiate their nuclear activities. In principle, under the NCAs, both states must be granted advance consent by the U.S. for their engagement in ENR activities when utilizing U.S.-origin material and in transferring the U.S.-origin spent fuel abroad for reprocessing. In addition, both states depend on the U.S. for their national security.
- ENR activities: Under the current U.S.-Japan NCA [8], the U.S. has given Japan programmatic advance consent for Japan's reprocessing and plutonium utilization, whereas it has not given the ROK the same treatment under the U.S.-ROK NCA [9]. In March, 2014, the current U.S.-ROK NCA was extended by two years [10]. Both governments had been "negotiating for a longer-term agreement, but have not been able to resolve key issues" [11]. It is reported that the ROK wants to obtain the U.S.'s programmatic advance consent especially with regard to pyroprocessing of spent fuel and utilization of recovered plutonium in the ROK, whereas the U.S. is concerned about nuclear proliferation in the Korean Peninsula, because "denuclearization of the Democratic People's Republic of Korea (DPRK) will be made even more difficult if the North Koreans can cite active fuel cycle programs in the South" [12].
- ENR facilities in the ROK and the DPRK: According to the "Joint Declaration of the Denuclearization of the Korean Peninsula" of 1992, both the ROK and the DPRK "shall not possess nuclear reprocessing and uranium enrichment facilities" [13].

Following is an analysis of this prospective MNA according to the twelve MNA features and their preconditions, as described in Box 1.

3.1.1. Analysis of Case Study 1

(A) Nuclear non-proliferation

Both Japan and the ROK are NPT members and have concluded international treaties and conventions on nuclear non-proliferation, including safeguards, nuclear security and export control. As mentioned in Box 1, if regional safeguards and RSAC are implemented, these actions would strengthen the nuclear non-proliferation characteristics of the MNA.

(B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services)

Neither state can offer ENR services due to the lack of ROK's and Japan's insufficient ENR capabilities. In this case, the participation of other states with such capacities in MNA and/or in ensuring supplies from other states through concluding NCAs is necessary. Alternatively, completion and enlargement of Japan's existing enrichment and expected reprocessing capacities would contribute to the assurance of supply. In addition, if the ROK would like to use its future pyroprocessing facility as a MNA facility, it needs to commercialize pyroprocessing technology.

(C) Nuclear safety

Both Japan and the ROK have concluded international conventions on nuclear safety. As mentioned in Box 1, if common nuclear safety standards and peer review systems are implemented, they would strengthen the nuclear safety characteristics of MNA facilities.

(D) Nuclear cooperation agreements (NCAs), (F) Siting: choice of host state of MNA facilities, (G) Multilateral involvement, (H) Access to technology, (K) Geopolitics and (L) Political acceptance

With regard to the fulfillment of feature (F), choosing a host state for the Japan-ROK MNA ENR facilities, the following three options can be considered:

- ✓ Option 1: Establish new MNA-ENR facilities in Japan utilizing its current ENR technologies.
- ✓ Option 2: Transfer Japan's existing ENR facilities to MNA facilities
- ✓ Option 3: Establish new MNA-ENR facilities in the ROK, including utilization of the ROK's pyroprocessing technology, although this technology is not yet fully developed.

As already mentioned, if the U.S.-origin material is to be utilized within Japan-ROK MNA-ENR facilities, the U.S.'s programmatic advance consent is necessary for a stable and smooth supply of nuclear fuel and nuclear fuel cycle services.

Regarding Options 1 and 2, considering the fact that Japan already has engaged in ENR activities, including reprocessing, by obtaining U.S. programmatic advance consent, and the transparency of the facilities would be further enhanced by the MNA's multilateral characteristic, obtaining this consent from the U.S. would be easy, on the condition that separated plutonium would be efficiently utilized as Mixed oxide (MOX) fuel, as is being utilized in France, Belgium and Germany, in the case of reprocessing.

In contrast, with regard to Option 3, as mentioned in Features (F), "Siting: choice of host state," and (K), "Geopolitics," host states of MNA facilities must be politically stable and maintain good relations with neighboring states. Considering the fact that "no final settlement (of the Korean War) was ever reached" [14] and in view of the Joint Declaration of the Denuclearization of the Korean Peninsula, the ROK cannot satisfy these conditions and, thus, it cannot host any MNA-ENR facilities. This situation is also a political challenge with regard to establishing a Japan-ROK MNA.

Another challenge is that the U.S. has not given its programmatic advance consent for the ROK's reprocessing. Fred McGoldrick and Robert Einhorn analyzed the U.S.'s reasons for not giving such consent to the ROK as follows [12,15,16]:

- ✓ The U.S. does not wish to jeopardize the satisfactory resolution of the DPRK's nuclear issue, including a nuclear weapon-free Korean Peninsula.
- ✓ Acceptance of the ROK pursuit of pyroprocessing may raise regional and global non-proliferation concerns.
- ✓ Preventing the spread of sensitive nuclear facilities is the U.S.'s long-standing policy, and it is challenging to find a rationale for making an exception for the ROK.
- ✓ The U.S. made exceptions for Japan, EURATOM and India in granting programmatic advance consent for their reprocessing because they had already built and operated reprocessing facilities. In contrast, the ROK's pyroprocessing technology is still in the experimental stage, and currently, the U.S. and the ROK are engaged in joint nuclear fuel studies.

All of the above reasons, except the last one, are highly political in nature and beyond the ROK's control. In contrast, as a potential means by which the U.S. could allow the ROK's pyroprocessing development, McGoldrick suggested the establishment of a U.S.-ROK "joint venture or multinational entity with IAEA involvement in the policy-making or management of the plant," noting that such an arrangement has the following advantages [15]:

- The U.S. can maintain its position of opposing the spread of sensitive facilities.
- The U.S. or multinational involvement could establish additional barriers, through transparency, to the diversion of nuclear materials to non-peaceful purposes, thereby serving as an important complement to international safeguards and physical protection.
- The presence of a multinational staff would place participants under a greater degree of scrutiny by partners and may also constitute an additional obstacle against a breakout by the ROK.

Considering the above advantages and to satisfy MNA Features (F), "Siting: choice of host state," and (K), "Geopolitics," it would be more desirable to establish a U.S.-Japan-ROK MNA with IAEA involvement, together with regional safeguards and RSAC. Participation by the U.S. and the IAEA would cause a Japan-ROK MNA to become more transparent and have more international characteristics, compared with only Japan-ROK MNA. Furthermore, U.S. participation would strengthen the MNA's function as a confidence and security building measure.

(E) Nuclear third-party liability (TPL)

Currently, neither state is a member of any international nuclear TPL convention. As mentioned in Box 1, for the purpose of ensuring adequate and prompt compensation, as well as maintaining equal and nondiscriminatory compensation among MNA member states for transboundary damage in case of a nuclear accident at the MNA facility, MNA members of neighboring states must participate in principle in the same international nuclear TPL convention. After the Fukushima nuclear accident, Japan decided to join the Convention on Supplementary Compensation for Nuclear Damage (CSC) in November, 2013 [17], while the ROK has already "modernized its nuclear liability legislations by introducing the major features" [18] of the Protocol to amend the Vienna Convention on Civil Liability for Nuclear

Damage and the CSC. In addition, if both states jointly participate in the CSC, the CSC itself will enter into force, because its requirements would have been satisfied.

(I) Economics

MNA facilities are expected to offer greater economic advantage than nation-based facilities. An existing Japanese enrichment facility offers a uranium enrichment production cost of approximately US$100/kg SWU (separative work units) [19]. Improvement of economic efficiency over this level would be required if the facility is to be utilized as an MNA facility.

As for the utilization of Japan's reprocessing facility as an MNA facility in the future, a past study determined that an MNA facility is more economically advantageous than a nation-based reprocessing facility, including transportation and if Kazakhstan is included in the MNA. This possibility will be further elaborated in Case Study 2.

With regard to the ROK's proposed pyroprocessing, the economic feasibility of pyroprocessing has been evaluated through joint nuclear fuel studies by the ROK and the U.S. [20].

(J) Transportation

Transportation by sea is expected between Japan's nuclear facilities and those of the ROK. This transportation should cause no major problems, because the routes would not cross into the territory of any other states.

3.1.2. Summary of Case Study 1

Table 1 summarizes the preceding analysis of Case Study 1.

Table 1. Summary of Case Study 1.

Features	A	B	C	D, F, G, H, K, L	E	I	J
Result of the analysis	√	X	√	Δ	X	X	√

Notes: √, satisfied; Δ, partly satisfied; X, not satisfied.

To establish the MNA, the following additional arrangements are necessary: First, with regard to Feature (B), to ensure the supply of enriched uranium and ENR services, the following options need to be considered:

- ✓ Participation of other states with ENR capacities in the MNA,
- ✓ Ensuring ENR supply from other states through NCAs,
- ✓ Enlargement of Japan's existing ENR capacities and
- ✓ Commercialization of the ROK's pyroprocessing technology.

The biggest challenges to the establishment of this Japan-ROK MNA relate to Features (K), "Geopolitics," and (L), "Political acceptance." In particular, the establishment of a new MNA pyroprocessing facility in the ROK would be difficult due to the current political instability of the Korean Peninsula and the lack of U.S. advance consent for ROK's commercial reprocessing through pyroprocessing. In this case, one possible solution would be an MNA including U.S. and IAEA involvement, regional safeguards and RSAC. Such a solution would enhance the transparency of Japan-ROK nuclear activities through direct U.S. and IAEA participation, and it would increase the

international nature of the MNA. Furthermore, U.S. participation could strengthen MNA's function as a confidence and security building measure.

Other necessary arrangements are as follows:

- (E) Nuclear TPL: both states need to participate in the CSC.
- (I) Economics: if existing Japanese enrichment facilities are to be used as MNA facilities, economic efficiency is required.

Implementing these measures could enable the establishment of a Japan-ROK MNA that satisfies all twelve MNA features and their preconditions.

3.2. Case Study 2

Case Study 2 assumes that nuclear operators in Russia, Kazakhstan, Vietnam, Japan and the ROK jointly form an MNA and transfer their existing facilities to MNA facilities. An advantage of this MNA is that with the participation of these five states and completion of both Russia and Japan's reprocessing facilities (which are currently under construction), the supply of every nuclear fuel cycle service, including spent fuel take-back, could be ensured without dependence on nuclear supply from non-MNA members, including the U.S.

Following is an analysis of this MNA according to the twelve MNA features and their preconditions as described in Box 1.

3.2.1. Analysis of Case Study 2

(A) Nuclear non-proliferation and (C) Nuclear safety

Russia, Kazakhstan, Vietnam, Japan and the ROK are all members of primary international treaties and conventions on non-proliferation, including safeguards, nuclear security and export control. In addition, these five states are members of the primary nuclear safety-related international conventions.

(B) Assurance of supply (of nuclear material and nuclear fuel cycle services)

In contrast with Case Study 1, the assurance of nuclear fuel cycle services supply, including spent fuel take-back (fuel leasing), within this MNA would be possible, thanks to each MNA member state's ability to fulfill the following roles:

- Natural uranium: Kazakhstan
- Uranium conversion and enrichment: Russia (and Kazakhstan, because it has a stake in Russia's Uranium Enrichment Center)
- Fuel fabrication: Kazakhstan, Russia, Japan and the ROK
- Reprocessing: Russia and Japan, with completion of their facilities
- Spent fuel take-back service (fuel leasing): Russia (Russian origin is necessary)

With regard to spent fuel take-back, Russian laws were changed in 2001 to allow bringing spent fuel into Russia for technological storage and/or reprocessing, but not for final disposal. However, according to ROSATOM, this spent fuel needs to be of Russian origin, not foreign origin [21]. This means that front-end supply would depend on Russia.

(D) Nuclear cooperation agreements (NCA)

These five states have already concluded NCAs with each other and with other non-MNA NSSs, such as the U.S. and France. In addition, considering the fact that every nuclear fuel cycle service would be ensured with the completion of Russia and Japan's reprocessing facilities, there would be little need to receive such services from providers outside the MNA, including the U.S.

(E) Nuclear third-party liability (TPL)

Currently, only Russia and Kazakhstan are members of the Vienna Convention on Civil Liability for Nuclear Damage, and Kazakhstan has also acceded to the Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (Revised Vienna Convention). Russia and Kazakhstan are in different parts of the Asian region from the other three nations; therefore, generally speaking, it is unlikely that an accident at a nuclear facility in either Russia or Kazakhstan would cause serious damage to Japan, the ROK or Vietnam, and *vice versa*. In this case, it is not necessary that all MNA member states must participate in the same international nuclear TPL convention, but only the pairs of Russia-Kazakhstan and Japan-ROK, which either share borders or are geographically close to each other. As mentioned in Case Study 1, Japan and the ROK must participate in the same international nuclear TPL convention, such as the CSC.

(F) Siting: choice of host state, (G) Multilateral involvement, (H) Access to technology and (I) Economics

Nuclear fuel cycle facilities already exist or are under construction in this MNA; therefore, there is no need to establish new MNA facilities if the existing facilities would be used. In addition, the utilization of such facilities has an economic advantage when compared with establishing completely new MNA facilities. In this case, non-ENR technology holder states cannot access such technologies, from the viewpoints of nuclear non-proliferation and protection of intellectual property.

(I) Economics, (J) Transportation and (K) Geopolitics

Economic comparisons between a nation-based and an MNA reprocessing facility and the economics of possible spent fuel transportation routes between Japan and Kazakhstan have already been considered in "A Study on the Establishment of an International Nuclear Fuel Cycle System for Asia" by the Nuclear Nonproliferation Study Committee, Graduate School of Engineering, University of Tokyo [22]. In this study, the following four scenarios were examined for the transfer of spent fuels from Japan to Kazakhstan where spent fuel storage was expected:

A: Via the Suez Canal and the port of Saint Petersburg,
B: Via the Arctic Sea and the port of Saint Petersburg,
C-1: Via the port of Vostchny, Russia,
C-2: Via the port of Lianyungang, China.

The study raised the following issues:

- The MNA is more economically advantageous than a nation-based facility under all scenarios, but it loses its economic advantage when the unit cost of land transportation is very high.
- The scenario via Lianyungang is economically advantageous under almost all transportation unit cost conditions, although this scenario does not use an existing route.

According to the study, Route C-2 "has no system to track the position of freight trains in real-time and there is a need to transfer goods at border stations due to railway tacks being different in Kazakhstan and China". However, compared with the alternative C-1, C-2 "had more stable winter weather and lower freight costs, so it is currently handling increasing amounts of freight as a primary rail transport route between Europe and Asia. If this route is further investigated and the problem of having to transfer freight a border stations between Kazakhstan and China solved and facilities for transferring nuclear fuel established in Lianyungang port in China, then hits could be a good choice for a transport route from Kazakhstan for the international nuclear fuel cycle" [22].

In addition, the study indicates the importance of China in nuclear material transportation, and in this respect, even if China is not an MNA member, the MNA needs to maintain a good relationship with China.

(K) Geopolitics and (L) Political acceptance

In Case Study 2, it is assumed that Japan and the ROK do not utilize U.S.-origin material within the MNA and fully depend on Russia for their fuel supply. In this respect, from the perspective of ensuring the energy security of Japan, the ROK and Vietnam, how to ensure reliable fuel supply from Russia would be a challenging political issue. In January 2009, Russia cut off gas pipelines to Europe via Ukraine, due to the failure of negotiations regarding gas prices with Ukraine's pro-EU government [23]. If any political conflicts occur between Russia and other states, including the U.S. and European nations, Japan, the ROK and Vietnam need to avoid being embroiled in those conflicts to maintain their energy security, although Japan and the ROK maintain a close relationship with the U.S. with regard to national security.

One possible solution would be to ensure alternatives of uranium enrichment service resources, including transportation routes, just as every nuclear utility in every state has already done as a preventive measure. However, the only other uranium enrichers are URENCO, AREVA and the U.S. Enrichment Corporation (U.S.EC), and therefore, both Japan and the ROK would have no other choice but to still depend on enriched uranium supply from Europe or the U.S.

3.2.2. Summary of Case Study 2

Table 2 summarizes the preceding analysis of Case Study 2.

Table 2. Summary of Case Study 2.

Features	A	B	C	D	E	F, G, H, I	I, J, K	K, L
Result of the analysis	√	Δ	√	√	Δ	√	√	X

Notes: √, satisfied; Δ, partly satisfied; X, not satisfied.

The great advantage of this Russia-Kazakhstan-Vietnam-Japan-ROK MNA is that assurance of nuclear fuel cycle services supply, including fuel leasing, would become possible with the completion of Russia and Japan's reprocessing facilities. In addition, this supply assurance could be achieved without U.S. involvement.

In contrast, the biggest challenges facing establishment of this MNA relate to geopolitics and political acceptance, just as in Case Study 1. To ensure stable and smooth supply of nuclear fuel and services within the MNA, the MNA needs to avoid being embroiled in any conflicts between Russia and other states, including the U.S. One possible solution for Japan, the ROK and Vietnam would be to ensure

alternatives of uranium enrichment service resources and transportation routes, so as not to depend fully on supplies from one state. Since the world's only other enrichers besides Russia are the U.S. and European states, in this respect, Japan and the ROK would still need to depend on enriched uranium supplies from Europe or the U.S.

To establish the MNA, the following additional arrangements are necessary:

- (B) Assurance of supply: Completion and enlargement of Russia and Japan's reprocessing facilities are necessary.
- (E) Nuclear TPL: As with Case Study 1, Japan and the ROK would need to participate in the CSC.

Implementing these measures could enable the establishment of this MNA to satisfy all twelve MNA features and their preconditions.

3.3. Case Study 3

In Case Study 3, it is assumed that nuclear operators in the six member states of the Cooperation Council for the Arab States of the Gulf (GCC), namely the United Arab Emirates (UAE), the Kingdom of Bahrain (Bahrain), the Kingdom of Saudi Arabia (Saudi Arabia), the Sultanate of Oman (Oman), Qatar and Kuwait, form an MNA.

Currently, there are no commercial power reactors in the GCC states. However, the UAE and Saudi Arabia have ambitious plans to newly install nuclear capacities by the early 2020s [24,25]. In contrast, the introduction of nuclear capacities in a politically unstable region close to Israel and Iran raises proliferation concerns. Israel is a *de facto* nuclear weapon state, while more recently, the P5+1 countries have sought to freeze Iran's uranium enrichment program in exchange for loosening economic sanctions on Iran. In this regard, efforts to establish MNAs or nuclear weapon-free zones have been proposed as follows:

- In December 2005, the GCC announced its initiative to declare the Gulf region a Nuclear Weapon-Free Zone (Gulf NWFZ) for the first time [26], as a first step toward establishing a Middle East Nuclear Weapon-Free Zone (MENWFZ) in the future.
- In December 2006, the GCC states announced their joint decision to establish a nuclear research program, and the GCC Secretariat and some GCC member states, respectively, asked for IAEA support for their projects.
- In October 2007, the GCC presented an initiative to establish an international uranium enrichment consortium in a neutral state outside the region through participation by interested states in the Middle East. However, the initiative was rejected by Iran, which insisted on continuing its own enrichment activities even if such a consortium were established [27].

The biggest difference between this GCC MNA and the other two MNAs in Case Studies 1 and 2 is that the GCC states are located in the Middle East, one of the most politically unstable areas in the world. Nicole Stracke states, "The past decades have shown that if one state in the Gulf region aims to achieve military superiority, other regional states will react decisively and try to restore the balance of power," and "in case the non-proliferation regime falls short in preventing certain regional states from developing their nuclear military capability … it is most likely that majority of the GCC states will seriously consider

joining the nuclear arms race as means of self-defense and as a necessary measures to protect their independence and security" [27]. In other words, if any one state in the GCC or elsewhere in the Middle East obtains a nuclear weapon, this may lead to a nuclear arms race. Therefore, nuclear non-proliferation needs to be especially enhanced in the region.

In addition, the GCC itself is a framework for the six states' national security against Iran. In this respect, if the development of GCC MNA nuclear facilities within the GCC territory encouraged Iran's nuclear activities and intensified existing proliferation concerns, the purpose of establishing the GCC itself would be inhibited. Therefore, host states of GCC MNA ENR facilities need to be carefully considered from the perspectives of geopolitics and political acceptance.

Following is an analysis of this MNA according to the twelve MNA features and their preconditions as described in Box 1.

3.3.1. Analysis of Case Study 3

(A) Nuclear non-proliferation and (C) Nuclear safety

As for safeguards, Oman, Qatar and Saudi Arabia have not yet ratified the IAEA Additional Protocol (AP), whereas Kuwait, Oman and Qatar have not yet ratified the Amendment to the CPPNM. Even if there are no nuclear facilities or activities, given the concern for ensuring nuclear non-proliferation and the fact that the neighboring states of Iraq and Iran promoted clandestine nuclear activities under IAEA comprehensive safeguards, it is necessary for MNA member states to adopt the AP. Alternatively, the GCC states would be able to establish a regional safeguards system equivalent to the AP, such as those adopted by ABACC.

Sara Z. Kutchesfahani has proposed the establishment of a "Middle East Regional Safeguards Organization" [28], suggesting that such an organization would have the following benefits:

- Development of confidence and trust building,
- Involvement of Middle Eastern states in the nuclear non-proliferation regime, such as ratification and implementation of AP and
- Development of further cooperation with others, including economic, technical and energy provision, as already demonstrated by the example of ABACC.

If this regional safeguards operation, together with RSAC, could be established and introduced within the MNA, the MNA itself would also contribute to trust, confidence and security building and nuclear cooperation. However, from a realistic viewpoint, the establishment of such an organization may be difficult, given the long history of political, territorial, religious, racial and tribal conflicts and deep-rooted hatred in the Middle East, which are not expected to vanish in the foreseeable future. In this respect, because the GCC has already been organized, the first step would be to create a "GCC Regional Safeguards Organization." If it worked effectively, then an effort to establish a "Middle East Regional Safeguards Organization" could follow [28].

Regarding Feature (C), "Nuclear safety," some states have not yet ratified nuclear safety-related international conventions. Since vulnerabilities of nuclear facilities from a nuclear safety perspective also become vulnerabilities from a nuclear non-proliferation perspective, potential member states of an

MNA would first need to ratify and implement international nuclear safety conventions and enact the necessary domestic laws governing nuclear safety.

(B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services)

Since none of the GCC states currently have nuclear capacities, the participation of other states with ENR capacities plus fuel-leasing capacities, if possible, in the MNA or the ensuring of supply through NCAs with other states would be necessary.

In this regard, the UAE is an exception. Its nuclear fuel and enrichment fuel service supplies are ensured by the U.S. in return for its commitment to forgo domestic ENR capabilities under the U.S.-UAE NCA and under its contract with the ROK for the construction of four APR-1400 reactors (Advanced Power Reactor 1400 MWe).

(D) Nuclear Cooperation Agreements (NCAs)

In the case of the GCC MNA, each GCC member state would not necessarily have to conclude NCAs with NSSs individually, since the GCC states as a whole, as an MNA, could conclude NCAs with NSSs.

Regarding NCAs between GCC states and the U.S., the U.S. has concluded an NCA only with the UAE, while Russia and France have NCAs with most of the GCC states. In this respect, the nuclear activities of the GCC states, except the UAE, are not necessarily affected by the U.S.

(E) Nuclear liability

Among the GCC states, the UAE and Saudi Arabia have acceded to the Revised Vienna Convention. This convention applies to its non-contracting states; however, if non-contracting states have a nuclear installation in their territory and do not afford equivalent reciprocal benefits, an installation state may exclude the application of the convention to these non-contracting states (Article 3 of the Revised Vienna Convention). Therefore, at this point, nuclear damage in Bahrain, Kuwait, Oman or Qatar caused by a nuclear accident in the UAE or Saudi Arabia would be compensated, because the former four states currently have no nuclear installation in their territories. However, if the former states pursued development of nuclear installations, they would also need to participate in the Revised Vienna Convention to be ensured of adequate and equitable compensation for transboundary damage.

(F) Siting: choice of host state, (G) Multilateral involvement, (H) Access to technology, (J) Transportation, (K) Geopolitics and (L) Political acceptance

As for Features (F) and (K), first, as mentioned in Box 1, the host state of an MNA facility needs to be politically stable. From this perspective, the GCC cannot host the MNA facility due to its geographic location near Israel and Iran. In addition, the GCC itself is a framework of six states for national security against Iran, although the six members' attitudes toward Iran are not necessarily the same. Therefore, the existence of MNA ENR facilities in the region should not become a threat to their national security.

Regarding Feature (F), "Siting: choice of host state," despite the GCC's 2007 initiative to establish an enrichment consortium, none of the GCC states, including the UAE, currently intend to host an MNA enrichment facility within their region, in view of the political instability in the region and the risk of activating Iran's nuclear energy program. Therefore, locating an MNA enrichment facility outside the region would be a rational idea. This is one way to avoid political challenges to establish the MNA. In addition, considering the fact that GCC states need to be supplied with nuclear fuel by NSSs, involvement of NSSs in the MNA would contribute to efficient functioning of the MNA. Since current major enricher states are also nuclear weapon states (NWSs), therefore the involvement of NSSs and/or

NWSs is necessary, and together with the regional safeguards mentioned above, the MNA's nuclear activities would become more transparent than if only the GCC member states were participants.

In contrast, there already exist uranium enrichment companies outside the region. In this respect, there would be an economic rationale for the GCC states as a whole to acquire a stake in several existing enrichment companies and receive assurance of enriched uranium supply in return. This could become another function of MNA, if the enrichment companies and their host states agree.

(I) Economics

Currently, there are no commercial power reactors in the GCC states; therefore, under present circumstances, establishment of ENR facilities, even within the context of an MNA, is not economically rational. In this respect, this MNA is only a potential future option.

3.3.2. Summary of Case Study 3

Table 3 summarizes the preceding analysis of Case Study 3.

Table 3. Summary of Case Study 3.

features	A	B	C	D	E	F, G, H, J, K, L	I
Result of the analysis	Δ	X	Δ	Δ	Δ	X	X

Notes: √, satisfied; Δ, partly satisfied; X, not satisfied.

First, since there are currently no commercial power reactors in GCC states, there is no economic rationale for having ENR facilities. In this respect, this proposed MNA is purely a potential future option.

At such a time when the GCC states would have an economic rationale for developing ENR facilities, the biggest challenges to establish this MNA would concern Features (K), "Geopolitics," and (L), "Political acceptance," just as in Case Studies 1 and 2. Because the GCC states are located very close to the nuclear threshold states of Israel and Iran, they cannot satisfy the preconditions for becoming a host state of an MNA facility of "political stability" and "good relations with neighboring states."

One possible solution to this political challenge would be to establish the MNA facility outside the region with the involvement of NSSs and/or NWSs in the MNA, along with regional safeguards and RSAC. These measures would make the GCC's activities transparent, as well as promoting confidence and security building among its member states. In addition, one expert analyst believes that a GCC safeguards organization would have the potential to grow into a Middle East safeguards organization in the future, as well as to create the GCC NWFZ and/or MENWFZ. Such NWFZs would contribute toward promoting not only nuclear non-proliferation and confidence building, but also nuclear disarmament and the peace process in the Middle East. Alternatively, there already exist uranium enrichment market and enrichment companies outside the region. In this respect, there would be an economic rationale for the GCC states as a group to acquire a stake in several existing enrichment companies and receive assurance of enriched uranium supply in return.

To establish the MNA, the following additional arrangements are necessary:

- (A) Nuclear non-proliferation and (C) Nuclear safety: Some states would need to ratify and implement the IAEA Additional Protocol (AP) and participate in international conventions on

nuclear safety. Alternatively, the GCC states could establish a regional safeguards system equivalent to the AP, comparable to the regional safeguards developed by ABACC.

- (B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services): to ensure supply, one or both of the following arrangements would be necessary:
  - ✓ Participation of other states with ENR capacities in the MNA and/or
  - ✓ Ensuring ENR supplies from other states through the conclusion of NCAs.
- (D) Nuclear cooperation agreements: Some GCC states would need to conclude NCAs with NSSs.
- (E) Nuclear TPL: GCC states with nuclear power facilities would need to participate in the Revised Vienna Convention, to which the UAE and Saudi Arabia have already acceded.

Implementing the above measures could make it possible to establish this MNA in such a way as to satisfy the twelve MNA features and their preconditions.

4. Conclusions

In this paper, in accordance with twelve MNA features and their preconditions, three case studies were conducted to discuss the feasibility of establishing MNAs comprising existing states in the Asian region and the Middle East. These case studies identified the challenges involved in establishing such MNAs along with possible solutions.

In all case studies, the political instability of member states and/or the region, supplier states' disapproval of sensitive activities within MNAs and political conflicts between NSSs and other states posed challenges to the establishment of MNAs. All of these challenges relate to MNA Features (K), "Geopolitics," and (L), "Political acceptance." There are no simple ways to overcome these challenges; however, as already clarified in the detailed discussion of each MNA feature, additional case-by-case measures, including direct involvement of an international organization, NSSs and/or NWSs in the frameworks, as well as the application of regional safeguards and RSAC among member states, could contribute toward mitigating the political challenges.

In this respect, it can be said that each MNA considered in these case studies could conceivably be established through application and implementation of the twelve MNA features.

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Author Contributions

Makiko Tazaki collected information and data and analyzed the results; Yusuke Kuno provided advice on the paper. Both authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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